Quantitative Models as an Aid in Offsetting Systematic Errors in Decision Making

An examination of how systematic errors occur in human decision making and how quantitative models allow users to recognize and exploit situations where our decision making is less than optimal.

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Master speculators have known since the formation of exchanges that information alone isn't enough to win the investment battle. They understand that you must also be able to get into the minds of your opponents and keenly understand how they will react to events. They knew that the price of a publicly traded stock was usually not its intrinsic value, but what people *think* it is worth. As Shakespeare said "There is nothing either good or bad, but thinking makes it so." Consider:

- Nathan Rothschild is the perfect example. In 1815, Rothschild maintained a vast network of private informants who were present at Napoleon's defeat at Waterloo. They dispatched this information to Rothschild via carrier pigeon, making him the only man in London with this information. The London exchange had been extraordinarily gloomy in the face of the prospects of an allied loss to Napoleon, with consol bonds trading 30 percent below par because of the uncertainty of how the map of Europe might look after the battles with Napoleon. The economics of the bonds were straight forward: they would go up if Napoleon lost and down if he won. Into this environment, blessed not only with advance information, but also a keen understanding of psychology, strode Nathan Rothschild. All eyes in the exchange fell on him, for most anticipated he would have access to early information. He sold. The panic that followed was natural given everyone's interpretation of this new piece of "information." All were certain he would sell only if Napoleon won, so they sold, heavily. Of course, it was into this panic which he and his representatives bought, getting in just before official word of Napoleon's defeat reached the exchange. He made a killing.[1]

- So too, do we find Edward Harriman, the railroad baron and stock speculator understanding the power of human emotion in the pricing of stocks. Asked if he could sell Southern Pacific, then at $70.00 per share, for $80.00 per share, he replied no, but he could move the price of the stock up to $150.00 per share and sell it down to $100.00. A $10.00 move would not ignite the imagination of the market, but an $80.00 spurt would create a broad market for the stock and have everyone falling all over themselves to buy at the bargain price of $100.00.[2]

These two situations offer a good look at how the ability to anticipate how others will react to "information" can give the investor or speculator a decided edge. This ability transcends an awareness that crowd behavior moves markets. It moves on to an understanding of how our underlying theories, biases, and beliefs influence how we will interpret data and what actions we will take based on these decisions. But how are we to take advantage of this today? Sole information to valuable information, such as Rothschild had, or the brazen willingness to manipulate stock prices, as with Harriman, are either impossible or illegal today. To understand how we can take advantage of this phenomena, we must first understand how willing we are to subjugate new facts to old theories; how much more limited our decision process is than we might have previously supposed, and how these limitations often put us in a situation of doing the wrong thing at exactly the wrong time.

Many, especially in the bright circles drawn to Wall Street, believe they possess a special, intuitive understanding of the overall workings of the markets and feel that they are uniquely qualified to anticipate and profit from the lemmings in the market. However, few are wise in the Socratic sense of "knowing what I do not know." The unpleasant truth is even the brightest can't avoid the magnetic draw of the crowd on their own. Witness Isaac Newton, one of the most brilliant men ever, lose a fortune in the South Sea bubble of 1720. The loss caused him to lament: "I can calculate the motions of heavenly bodies, but not the madness of men."[3]

Fewer still have an innate ability to move against their own underlying theories at the correct time. Because of the way we process information, it's close to impossible to make appropriate decisions when we are faced with the one, two punch of trying to fit new facts to old theories, **and** keep

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1. Maital, Shlomo, *Minds, Markets, & Money: Psychological Foundations of Economic Behavior* (New York: Basic Books, 1982).

2. Thomas, Dana L., *The Plungers and The Peacocks* (New York: William Morrow and Co., 1989).

3. Sharp, Robert M., *The Lore and Legends of Wall Street* (Homewood, Illinois: Dow Jones-Irwin, 1989).

ourselves in a comfortable segment of the mainstream, or crowd, opinion.

While much as been written about crowd behavior and it's affect on stock prices (see for example David Dreman's *Psychology and the Stock Market*) we would like to focus on studies which show that people's decision making process is far more limited than previously supposed and that this directly affects the quality of our decisions. These studies also reveal the broad scope theories and ideas play not only in what facts we choose to focus on, but also how we utilize those facts in the formation of decisions for action. From these examples we will show how systematic errors, caused by faulty reasoning and decision making, coupled with the natural tendency for emotions to take over from reason at market extremes and turning points, are created and how the use of simple, quantitative models may help us recognize times when a "system error" or blind spot has occurred and may be exploited. Unless otherwise noted, all of the following examples are reported in *Human Inference: Strategies and Shortcomings of Social Judgment* by Richard Nisbett and Lee Ross; *The Limits of Scientific Reasoning* by David Faust; *Decision Making: Descriptive, Normative, and Prescriptive Interactions*, a collection edited by David E. Bell, Howard Raiffa, and Amos Tversky ; *Minds, Markets, & Money: Psychological Foundations of Economic Behavior* by Shlomo Maital and *How Real Is Real?: Confusion, Disinformation, & Communication*, by Paul Watzlawick.

As Thomas Kuhn points out in *The Structure of Scientific Revolutions*, theories have a definable life cycle and in many instances generate the very proofs which supposedly prove the theory. The theory itself guides what facts one finds, such that, after we have decided to agree with the theory, we react to information which differs with it negatively, even if it is objective and highly relevant. Fact and theory become inseparable, with the underlying theory guiding the investigation. What one finds is determined in large part by the assumed underlying structure, such that your frame of reference influences what you find. In fact, examples abound of people desperately doing **anything** to save a favored old theory, as when the ancient astronomers continued to add circles to the orbits or planets in an attempt to make the theory reflect the new data made available from better observation. Eventually, such theories collapse of their own weight of inconsistencies, but it takes a great deal of time from when the new information was made available. How does this affect our decisions? It biases them by putting blinders on us, helping us ignore new information which may in fact differ with our theory and lead to new, better ideas about what to do. In the market, for example, we see one set of theorists with an unshakeable belief in an efficient market setting up tests to "prove" their theory while at the same time another group has also designed successful tests "proving" the market is inefficient and filled with ways to beat the market as a whole. And while Einstein went so far as to say "It is the theory which decides what we can observe," we'll settle for the simple observation that human bias is ever present. Consider:

- Tests show that people maintain *a priori* hypothesis even when presented with conflicting data. In fact, they will reinterpret ambiguous data as if it supported their hypothesis. This creates what are known as "self-sealing" premises, were the premise is vindicated not only by proof, but by disproof as well!

- People misuse samples; generalize from the particular by making sweeping connections on the macro level from single observations; believe in "the law of small numbers" by assuming a transitivity between small and large samples with an assumption that small samples conform to the same laws of chance applicable to large samples, even when every elementary statistics course teaches that it is in small samples where we see the largest deviation from the mean. Variance decreases with sample size, with a larger sample conforming more closely with the laws of probability. The obvious problem this creates is the inherent bias and misuse of samples which cause faulty probability guesses.

- People invent casual explanations for events even when it can be demonstrated that regression to the mean is responsible. They then allow these causal explanations to guide them in other decision making processes.

- We form judgments on the probability of an event based upon the ease with which we can recall instances of the event! Ease of recall is directly linked to the vividness of the event. Vividness

increases with how removed from the norm the event is, thus the old saw about a dog biting a man not being news, but a man biting a dog, that's news for the front page. When such an unusual event occurs, it gains our attention by being so removed from the norm and becomes a **focal point** for our attention, and thus more easily remembered. This can cause tremendous problems when trying to make an educated guess at the probability of an event, and what action we should take in regard to it. Consider that people actually change their travel plans to Europe after a rash of terrorist attacks even though the probability of dying in Europe at the hands of a terrorist are quite a bit lower than drowning in your bathtub.[4] The immediate problem this causes is the tendency to forever overweight the exceptional and unusual and underweight the normal and everyday. This leads us to a position of consistently overestimating small probabilities, with rare and costly disasters overly feared and rare and large gains overly anticipated. This is an excellent example of how a knowledge of the true risks involved can give you an edge if it differs substantially from the current *perceived* risk: for the European traveler, lower room rates perhaps. For the Stock market investor, an opportunity to profit. The miscasting of risk in such a manner also leads to ignoring the powerful indicator of the null hypothesis. That Sherlock Holmes knew that the dog **must** have known the intruder because he **didn't bark**, is an excellent example of the use of the absence of information being used for decision making. It is one that is dramatically under utilized by the average forecaster.

- Another common error in decision making linked with vividness is over reliance on our own personal experience. This can lead to costly and wrong forecasts simply because our own experience gets in the way of a reasonable forecast. An excellent example is the 1972 Presidential campaign. All of the reporters, and they a normally cynical lot, who covered George McGovern unanimously agreed that he could not lose by more than 10% of the vote. They said this even though everyone of them knew he was 20% behind in the polls and that no major poll had been wrong by more than 3% in 24 years. Why did these tough, intelligent people bet not only against the base rate spread of 20%, but also their own savvy? Because of the concrete evidence of their personal experience. They were there and saw the huge crowds of supporters, felt their enthusiasm vividly, leading them to a forecast which was way of the mark. In much the same way, a market analyst who has been to the company and knows the president and inner workings of the operation may end up ignoring what his statistical analysis is telling him in favor of his first hand impressions. In social science terms, he's over weighting the vivid and under weighting the "pallid" statistics which can lead to costly forecast errors when you are working with a large sample.

- In much the same spirit, we see people constantly misusing base rate information. Base rates are information about the prior probabilities, central tendencies and proportions of the occurrence of events. Studies have found, however, that people will make full use of base rate information only when there is a lack of descriptive data. For example, in one of the tests conducted to study this phenomena, people were told that out of a sample of 100 people, 70 were lawyers and 30 were engineers. When provided with no additional information and asked to guess the occupation of a randomly selected 10, people used the base rate information, saying 7 were lawyers and 3 were engineers. However, when worthless yet descriptive data is also added, such as "Dick is a highly motivated 30 year old married man who is well liked by his colleagues," people largely ignored the base rate information in favor of their "feel" for the person. Finally, when specific and stereotypical information was added, such as "Dick is 30 years old, married, shows no interest in politics or social issues and likes to spend free time on his many hobbles which include carpentry and mathematical puzzles" was added, people totally ignored the base rate and respond to the personality profiles according to which is the most "engineer-like" or "lawyer-like."

- The above shows how strongly we rely on default assumptions for making decisions. Default assumptions are built up on a life of experience, and are very useful in decision making, provided we don't allow other relevant information to slip by, such as that of the base rate. But for the most part, our default assumptions are based on our theories of how things work. The problem is, as

4. Paulos, John Allen, *Innumeracy: Mathematical Illiteracy and its Consequences* (New York: Hill And Wang, 1988).

noted previously, we retain *a priori* assumptions about things, cause and effect among them. Thus, studies have found a consistent bias on the part of most people which links great events to great cause; complex events to complex causes; rational to rational; etc. This attribution error persists even in the face of new research which suggests that in many instances, complex events can have their origins in simple, seemingly unrelated causes.[5] As previously mentioned, we will also invent casual explanations where non exist. Experiments in noncontingent rewards, or rewards were the subject believes that the reward is contingent upon his performance, when in fact it is not, offer good examples of this phenomena. In experiments with rats, experimenters would release a rat from his cage into a path which had a food tray at the end of it. Under normal conditions, the rat would take around 2 seconds to get to the tray. However, the food would only be dispensed if the rat got to the tray 10 seconds after being released. Thus, the rat would have to find a way to kill 8 seconds if he wanted the food. What happened was the rat, in trying to figure out how to get food to appear, would do jumps, pirouettes, etc. and then, quite accidentally, the rat would kill over 10 seconds and food would appear. From that point on, the rat would faithfully repeat the actions which he did prior to getting the food the first time, with each subsequent dispensing of food "confirming" his belief that it is the particular action which is "causing" the food to be released. Pavlov did similar experiments with pigeons and arrived at similar findings. More importantly, research dealing with humans in this area shows similar findings, and will be detailed later in this paper.

- Studies of people ranging from scientists to horse handicappers found that people made decisions based on the first few bits of information to reach them. Herbert Simon, a 1978 Nobel prize winner, thinks we can digest only 5 to 7 things at once, thus it may be that the first 5 to 7 bits of information to reach us are seriously over-weighted. Additional information did not aid their decision making ability, and in fact, some studies concluded that additional information tends to **decrease** predictive ability. This is known as the dilution effect. When a mixture of diagnostic and nondiagnostic information is used in multi-factor models, researchers found that as little as two worthless items could dilute the effects of items found to be highly relevant. People did use the additional information to bolster their conclusions however. Many went so far as reinterpreting contrary information and saying it supported their position and labeling studies that supported their own belief as "better conducted" and "more valid."

Implications for the Market

We've seen from a review of experiments not often cited with regard to the stock market how even the most simple decision making process can be distorted not only by a misperception of relevant data, but also by an incredible reluctance to give up on a theory, hunch or idea once we've accepted its validity. When these errors are thrown headlong into a system which exhibits a great deal of group think, with positive system feedback always present to reinforce the popular perceptions, we get a situation which allows for booms and busts, manias and panics. Now we must look at how we might take advantage of our own shortcomings, much the same way that Rothschild and Harriman did, but instead of using their mastery of questionable techniques, we will show how utilization of an objective, mathematical asset preference model can help us identify blind spots in our own behavior and hopefully save us from unnecessary exposure to risk.

The stock market is a complex (e.g., as contrasted to simple ordered systems or random, chaotic systems), anticipatory system, based mostly on:

a) Our recent experiences in regard to our previous forecasts and the actual outcome of those forecasts, time weighted to give the greatest amount of weight to the most recent experience.

b) Our perceptions of current conditions, adjusted most likely by the error factor of our last forecast.

c) Our expectations for the possible range of future conditions modeled down to a net, best guess estimate of the majority of investors for the next period.

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5. See for example a discussion of the butterfly effect in books such as James Gleick's *Chaos – Making a New Science* which discuss the recent developments in Chaotic Mathematics.

d) Random shocks and disturbances to the system and our reactions to them.

e) Positive system feedback.

The system becomes one which fairly quickly reflects the current consensus, best guess estimate for what the next period will bring. This efficiency of rapidly reflecting current forecasts is by no means a guarantee of the correctness of the forecasts however. The market shows high efficiency at the short term, stale news level, with any discrepancies quickly arbitraged away. This efficiency does not appear to extend to the markets job of correctly moving the longer term price structure to levels which efficiently reflect intrinsic value of the underlying assets. It is here that the market is always aiming at a moving target and forever hitting too high or low, with a great deal of the mispricing occurring because we allow our hearts to take over from our heads at tops and bottoms. In fact, as we've seen from the above examples, people make decisions rather quickly and on a limited amount of information. They then change their outlook from an active *questioning mode* to a *confirmation mode*, or one that no longer seeks out all information but rather one which seeks out information which confirms the decision. In many instances, decisions such as "I will buy" or "I will sell" are made rapidly, but implemented only after the person has had a chance to become comfortable with that decision, usually by "marshaling the facts" and building a weight of the evidence model to support the correctness of the decision. The result of such activity is the creation of time lags between the point a decision is made and the point it is implemented. The time in between is taken up by a building of a weight of the evidence model which is in essence an attempt to create comfort with the correctness of the decision. It is this lag which offers the opportunity to objective, non-emotional models.

Consider two decision paths at time 1: The first path, A, has the support of a majority of your peers and a majority in the market, has recent market validation, and a great deal of credibility in the form of publicly available information which supports the position. The "facts" currently weigh very heavily in its favor. The second path, B, has no peer or market support; has little evidence in it's favor and has no current market validation. The first path is so appealing, so self evident and so backed by the "facts" that it would take a will of iron not to want to go down it. But, in many cases, the risk is highest when the majority finally come to believe in the inevitability of the hoped for outcome. Thus, you see Path A as reflecting positions such as that held by one of the best selling financial advice books of all times, written in the early 80's, and telling everyone that during the inflationary 80's, gold would be over $2,000.00 an ounce and that interest rates would exceed 40%. The book was a bestseller even though it offered almost exactly the wrong advice. So too do we see a Path A thinking in operation when, only months before one of the biggest bull markets in history, a prestigious business magazine heralded "the death of equities" from its cover. We bring these points up not to make those involved look bad but rather show how persuasive weight of the evidence models can be in a dynamic system.

Objective, mathematically based models, on the other hand, generally follow Occam's Razor which suggests that many times it is the simplest, most understandable solution which is the correct one, and base their inputs on a few mathematical variables which the model designer believes have a consistent reliability in judging the market. What the models generally avoid is the time lags. They do this because they issue a recommendation right after moving out of the *question mode*, without ever moving into the longer confirmation mode. Thus, they ignore the emotions which usually take over at market turning points, and are able to "look through" the shorter term emotions to the longer term trend with regard to price structure. Another key to the success of quantitative models is the fact that they allow no override of the model's path to action. They consistently apply the same rules time and again, and this is one reason they do so well when compared to human forecasters.

In fact, many tests have shown that human judges, be they clinical psychologists making predictions about patient outcome, analysts making projections for earnings growth, or college admissions officers making predictions about how well new students will perform, almost always show inferior predictions in the face of empirically derived actuarial formulas, which use only a few attributes which are known to be associated with outcome.

The intuitive forecasters are not only worse than optimal regression equations, they tend to be worse than **any** simple formulas, even those were the weights given to various attributes in the equation are arbitrary, as long as the are non-zero, positive and linear.[6] Why? Not only do we as intuitive forecasters apply invalid weights, we do so unreliably: once using a piece of data, another time rejecting it, depending on how we feel or the circumstances. Access to a non-emotional, fact based model would at least allow the intuitive forecaster to have a foil to contrast his own decisions against.

One more study is worth reporting, for it neatly summarizes some of the difficulty we face when we are not willing to at least have access to a non-emotional model for guidance in our decision making, and also how we tend to prefer the complex and the artificial as opposed to the simple and unadorned.

Professor Alex Bavelas designed a fascinating experiment in which two subjects, A and B, are seated facing a projection screen. There is a partition between them, so they can not see or communicate with one another. They are told that the purpose of the experiment is to learn how to recognize the difference between healthy and sick cells. They are told they must do this by trial and error. In front of each are two buttons marked "Healthy" and "Sick," respectively, and two signal lights marked "Right" and "Wrong." Every time a slide is projected they have to make a guess by pressing one of the buttons, whereupon one of the two signal lights will flash, informing them if they are correct or not. Subject A gets true feedback, with his situation being one of simple discrimination. In the course of most experiments, Subject A learns through this method to distinguish healthy from sick cells with a degree of accuracy of around 80%.

Subject B's situation is entirely different. His feedback is based not on his own guesses, but on A's. Therefore, it does not matter what he decides about a particular slide, he is told he is "right" if A guessed right, "wrong" if A guessed wrong. B does not know this, he has been led to believe there is a true order which he can discover by making guesses and getting feedback. He ends up searching for an order when there is no way that *he* could discover it.

A and B are than asked to discuss what they consider to be the rules for judging which cells are healthy and which are sick. A's explanations are simple, concrete and to the point; B's are out of necessity subtle, complex and highly adorned. After all, he had to form his opinions based on contradictory guesses and hunches.

The amazing thing is that subject A doesn't think B's explanations are absurd, crazy or unnecessarily complicated. In fact, A is impressed by their "brilliance" and tends to feel inferior and vulnerable because of the pedestrian simplicity of his assumptions. The more complicated and ornamentally abstruse B's explanations, the more likely they are to convince A.

Before the next test with new slides, A and B are asked to guess who will do better than in his first test. All Bs and most As say that B will. In fact, B shows hardly any improvement, but comparatively seems to be doing much better because A, who now shares some of B's abstruse ideas, performs significantly worse than the first time.[7]

How many times have we faced similar situations in the market, with the extraordinarily complicated drawing us not because it makes the most sense but rather because it allows us to find justification for continuing an investment policy which has ceased to make sense and now requires a variety of subtle, complicated arguments to support its continuation.

Summary and Conclusion

We are subjected to and bombarded by an immense amount of information and data on a daily basis. We many times should be willing to say, "this is just a restatement of or a clarification of data x" but we do not. We filter the information

6. We recommend that readers interested in this phenomena read *The Limits of Scientific Reasoning* (Minneapolis, Minnesota: University of Minnesota Press, 1984) by David Faust in its entirety.

7. Again, readers interested in this topic would do well to read the entire text from which it was taken, *How Real Is Real: Confusion, Disinformation, & Communication* (New York: Vintage Books, 1977) by Paul Watzlawick.

and give it weight according to our previous concepts and ideas, and how well it either supports or rejects our underlying theory or position. We will go to remarkable lengths to protect our *a priori* hypothesis, including the reinterpretation of data which objectively appears to contradict our position as supportive of our position. If this is impossible, we will many times reject the data as flawed or irrelevant under what we view as "special" circumstances. In this way, we create systematic errors in judgment which can lead to serious misvaluations regarding the intrinsic worth of assets not only with regard to their own history, but also on an inter-market basis as valued against other assets.

We tend to make decisions on a shockingly small amount of data which is time weighted to favor the most recent period. We then move rather rapidly from a *questioning mode* to a *confirming mode*, in which we seek out data which supports the decision we've made. As we build these weight of the evidence models, we reach a point were our comfort level with the decision is sufficient and we then act on the decision. With the perspective of a long term outlook, we see that trends emerge from our acting on decisions, and that they tend to persist for a fairly long period, with positive feedback acting as a reinforcing agent to the consensus viewpoint. When this consensus becomes firmly established, blindspots to data which differs from the consensus viewpoint develop, with the size of the blindspot generally a function of how much current data supports the majorities point of view. It is at this critical point where quantitative models offer the greatest utility, as they are unemotional, consistently applied, fairly simple and straight forward methodologies based on relationships the model's designer has found to be relevant and useful in gauging an impending change in either the underlying conditions or how those conditions are perceived by market participants. These models offer several benefits to the user. They are often based on Occam's Razor which suggests that many times the simplest solution is the correct one. If they are based on uniform paths of action, they will always use the same criteria to make decisions and recommendations and are therefore not subject to the same unreliable utilization of data and the weighting thereof, one time using the data and another time ignoring it, which is a problem that tests have demonstrated plagues the intuitive forecaster. Humans may be better equipped to select which variables should be used, but we seem unable to ignore our emotions and accept the variables advice at critical turning points.

Finally, access to a quantitative model should enhance the performance of market participants by adding yet another tool to their investing tool kit and serving as a red flag at precisely the times when our emotions are leading us in the wrong direction.

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